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ABSTRACT

The purpose of this study was to adapt the Hidden Figures Test (a measure of field dependence/independence) to microcomputer display and to assess its alternate form reliability when compared to a paper and pencil test. Participants included 58 undergraduate and graduate students (91.4% female) at a southeastern university who were fairly normal in regard to the task measured by the test. One group (N=38) was administered the print version of the test first, followed immediately by the computer version. The other group (N=20) received the computer version first to control for order effect. For the group who received the paper version first, the mean scores on both tests were equivalent (M=4.71); however, for the group receiving the computer version first, scores were significantly lower on the computer version (M=2.55) than on the paper version (M=5.20). The significant order effect found for the first group raises serious questions about the face validity of a computer version of the Hidden Figures Test, suggesting that additional research is needed before construct and face validity are assumed between alternative forms of test administration. (JB)

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EFFECTS OF MICROCOMPUTER DISPLAY ON A PERCEPTUAL/COGNITIVE TASK

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INTRODUCTION

Toward Adaptive Courseware Designs

Assuming that computers will play an incresingly intergral role in the educational and training of individuals in school and non-school settings, more effective ways of utilizing their potential should be investigated. Courseware producers are beginning to transcend the conceptual and instructional constraints imposed by the form of most drill-and-practice and tutorial software. Future efforts should focus, at least in part, on exploiting the interactive and adaptive capabilities of computer assisted instruction rather than merely using the computer as a presentation device for text and graphics. These capabilities permit greater flexibility in courseware than merely providing remedial responses to multiple choice questions. Several levels of interactivity between the user and the computer are possible, as are multiple levels and dimensions of possible adaptations by the courseware to those interactions (Jonassen, 1985). A potentially important adaptive, interactive courseware design diagnoses learners' intellectual skills and/or cognitive styles prior to instruction and then adapts the instructional presentation to capitalize on the individual learner's processing strengths or to remediate the learner's skill weaknesses (Carrier & Jonassen, in press). Ross (1984) recommends "greater emphasis ...on pretask assessments (eg. of prior achievement, learner backgraound, etc.) as bases for adaptation" (p.47). Only through increasingly sophisticated adaptive sequences will the computer begin to realize the tutorial potential of a Socratic dialogue.

Assessing Learner Differences

Many measures of individual differences have evolved from individual, projective tests to take the form of non-projective, paper-and-pencil tests in order to improve the efficiency of the test while maintaing reliability and validity. For instance, the cognitive style, field articulation has evolved from the Body Adjustment Test, which required elaborate apparati, to the Rod and Frame Test, with less elaborate apparati, to the individual paper-and-pencil Embedded Figures Test, and finally to the group administered Group Embedded Figures Test and Hidden Figures Test. The next step is to embed these latter tests into courseware as a means for diagnosing learners' processing preferences. Can we assume that these tests are adaptable to computer display without affecting performance? How will adaptation of these tests to computer display affect their validity and reliability? Will the limited resolution of computer generated graphic presentations affect the information processing requirements of the task?

If instructional adaptations are to be predicated on computer tests of cognitive and perceptual tasks, we need to be certain the computer testing requires the same perceptual and intellectual processes as the paper-and-pencil forms.

Purpose of the Study

The purpose of this study was to adapt the Hidden Figures Test to microcomputer display and to assess its alternate form reliability when compared to the paper-and-pencil test. The Hidden Figures Test (Ekstrom, French & Harmon, 1976) is a popular measure of the cognitive style, field articulation, otherwise known as field dependence/independence. It measures the ability of the subject to perceive and separate information from its surrounding contextual field. Specifically, subjects are required to locate one of five simple figures in several complex patterns (see Figure 1). Subjects who are adept are field independent. They are skilled at separating stimuli from their surrounding perceptual field, that is, their perception is indepedent of the perceptual field in which it is embedded. Field independent subjects are not only more skilled at locating figures in patterns, but also in problem solving and other cognitive tasks requiring learners to select salient cues from their surrounding contextual field, as well as imposing their own structures on information (Witkin et al, 1977). In short, they are more analytical processors of all forms of information. These processing differences are reflected in their social interactions and career choices, with field independents preferring greater interpersonal distances and fewer interpersonal relations. Field articulation has also been related to intelligence, hemispherical preference, deductive reasoning , and a host of other constructs. Since it is one of the most reliable and certainly the most researched cognitive styles, reflecting the most distinguishable processing differences, it it was selected to test the effects of microcomputer display. In a study virtually identical to this one only recently discovered after collecting the data, the paper-and-pencil form of the test produced higher scores, though the alternate form reliability was significant, $r=.57$, $p<.05$ (Jacobs, Byrd, & High, 1985). Only 32% of the variance was explained, however, indicating a weak alternative form reliability. Despite my intention, this study may function as a replication of the earlier study.

METHOD

Instruments

The Hidden Figures Test, Form CF1, Revised, is from the Kit of Factor Referenced Cognitive Tests (French, Ekstrom & Price, 1976). It consists of two parts, each with 16

complex patterns in which are embedded one of five simple figures (see Figure 1). Part one, questions 1-16, was used in its paper-and-pencil form. Part two, questions 17-32, was converted to computer display. It was programmed in Applesoft BASIC for display on 12 inch, monochrome (green screen) monitors with Apple IIe computers. The figures and patterns were constructed in page 1 of Apple high resolution graphics. This provided a four line text window at the bottom of the screen for giving directions. Resolution in this mode is 280 horizontal pixels by 160 vertical pixels. All of the figures and patterns in the computer version were identical in proportion nearly identical in size to those in the paper-and-pencil version. The timing and scoring were the same. The instructions for how to perform the task were taken verbatim from the paper version. To those were added instructions in how to manipulate the screens. The primary difference between the versions was in the number of patterns visible to the subjects at any time. In the paper-and-pencil version, the 16 figures are displayed on two pages, with 3 rows of patterns on each page. Four of those rows contained 3 patterns, and the last 2 contained 2 patterns per row. Because of limited size of the computer terminal, the three rows of figures could not be displayed simultaneously. So, the five simple figures were always displayed at the top of the screen with a single row of patterns (either 2 or 3) displayed in the middle of the screen (see Figure 2). The rows appeared in the same order, arrangement, and proportion as they did in the paper-and-pencil test. Subjects could flip between each of the rows simply by pressing the right or left arrow keys at the bottom of the keyboard. The computer required 1.2 seconds to clear the screen and form the new row of figures. The numbers of the patterns were displayed directly beneath each pattern. The other difference between the two versions was in how the subjects recorded their answers. In the paper-and-pencil test, the letters A-E (corresponding to the figures in the top row) were displayed beneath each pattern. The subjects were instructed to circle the letter corresponding to the figure which they thought was embedded in the pattern. In the computer version, when subjects wanted to answer, they pressed the letter A (for answer). In the text window at the bottom of the screen, they were prompted: "In which pattern did you find a figure?" They were instructed to type a number between 1-16 followed by a return. Any other response but a number between 1-16 resulted in a remdial message instructing them to respond with a number between 1-16. They were next prompted: "Which figure did you find in pattern pattern number?" They were prompted to respond with a letter A-E and a return. They were then given confirmation of their response with the opportunity to alter their response, "Figure __ is in

Pattern __. Correct (Y or N)?" A "y" typed in would clear the text window, except for the screen manipulation prompts. All other keys on the keyboard, except the numerals and the letter A-E, Y, and N were deactivated.

Participants

The participants included 58 upper-level undergraduate and graduate students in education and library science at a southeastern university. They were predominately (91.4%) female. The mean score for all subjects was 4.96, which is equivalent to norms for this group established in other investigations. So the participants in this student were fairly normal with regard to the task measured by the test. All subjects had some prior experience with microcomputers, though the level of experience varied.

Procedure

One group (n=38) was administered the print version of the test first, followed immediately by the computer version. The other group (n=20) received the computer version first, in order to control for order effect. The tests were always administered in immediate succession. The only delays incurred were for changing rooms, ie. moving to and from the computer lab, which was less than 100 feet away. For each adminstration, the experimenter read the instructions and the subjects completed the sample test items. Any questions were answered prior to the beginning of the test. The Hidden Figures Test is a timed test. Subjects were given 12 minutes to complete each version of the test.

RESULTS

Pearson product momment correlations were calculated for the paper-and-pencil and computer versions of the test. There was a significant relationship between the two versions, r=.484, p<.05. The significance of this relationship should be tempered by the fact that the relationship accounted for only 23.4% of the variance between the scores.

In order to test for order effect, a two-way analysis of variance was calculated for the mean scores presented in Table 1. Table 1 indicates that for the group which received the paper version first, the mean scores on both tests were equivalent (M=4.71). However, for the group receiving the computer version first, their scores on the computer version were significantly lower on the computer version (M=2.55) than on the paper version (M=5.20). The analysis of variance indicated no ma.n effect for order of treatment. The paper first group performed better (M=4.71) on the combined scores than the computer first group (M=3.875), however the difference was not significant. There

was a significant main effect for version of the test, $F=5.12$, $p<.01$. Scores for the paper version ($M=4.96$) were higher than the scores for the computer version ($M=3.63$). The interaction was also significant, $F=5.12$, $p<.05$, indicating a significant order effect for the computer first group only. When the subjects received the print version first, they performed as well on the computer version. However, when they received the computer version first, their performance on the print version improved significantly.

DISCUSSION

There is evidence which indicates that by adapting perceptual and cognitive test, such as those for field dependence/independence, you lose both face and construct validity. Streibel (1981), in a series of experiments with the Embedded Figures Test, found that by increasing the size of the embedded figures by a factor of eight, the nature of the performance was altered. Field dependent subjects became more field independent, and field independent subjects became more field dependent. In this study, serious questions about the face validity of a computer version of the Hidden Figure Test were raised. While there was a significant correlation in the scores on both version of the same test, the analysis of variance indicated that they could not be judged alternate forms of the same test. The performance, as a function of order of testing, varied too extensively. This is especially important when we consider that in a computer managed instructional environment, where the computer would conduct the diagnostic testing, the computer version would replace the print version. The scores on the initial administration of the computer version were significantly lower than the initial administration of the paper-and-pencil version. This lower score corroborates the conclusions of Jacobs et al (1985) that the computer version is probably measuring other constructs such as computer anxiety, which is a function of prior computer experience. There was anecdotal evidence that the perceptual constructs being measured were also different. A number of subjects, especially those in the print-first group thought the computer version was easier, because the diagonal lines generated by the computer (2 pixels wide) were easier to distinguish and compare. Obviously, additional practice with performing perceptual tasks on the computer may well have reduced the effects of computer testing in this study. Additionally, the use of a higher resolution screen may have produced more equivalent performances. This study should be replicated, adding at least one more level of resolution as a test for that factor. The use of computers to administer perceptual and

cognitive tests is clearly in the developmental stage. A lot of additional work is necessary before we can assume construct and face validity between alternate (computer vs. print) forms of administration.

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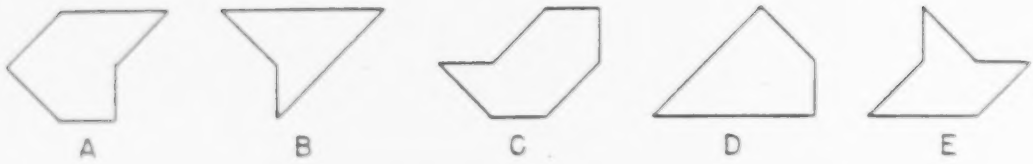
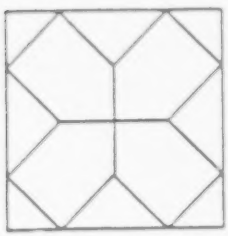
Table 1
Mean Scores by Group on the Hidden Figures Test

	Test		
	Paper HFT	Computer HFT	
Order			
Paper-Computer	4.71	4.71	4.71
Computer-Paper	5.20	2.55	3.875
	4.96	3.63	

Part 1 (12 minutes)



1. 

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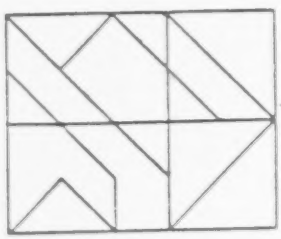
2. 

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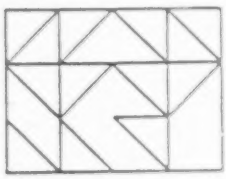
3. 

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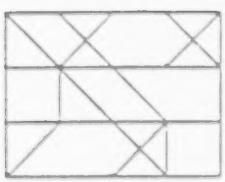
4. 

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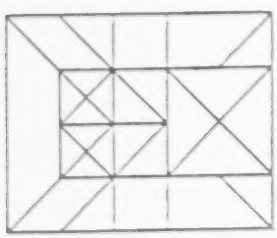
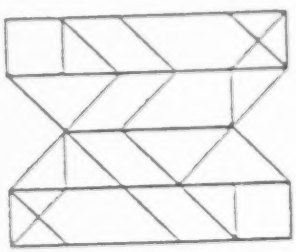
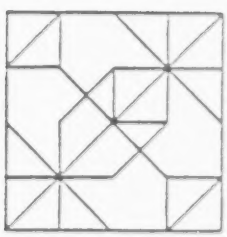
5. 

A B C D E

6. 

A B C D E

7. 

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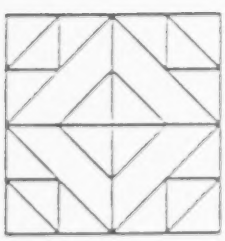
8. 

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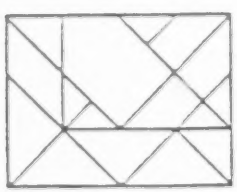
9. 

A B C D E

Figure 1
Paper-and-Pencil Version

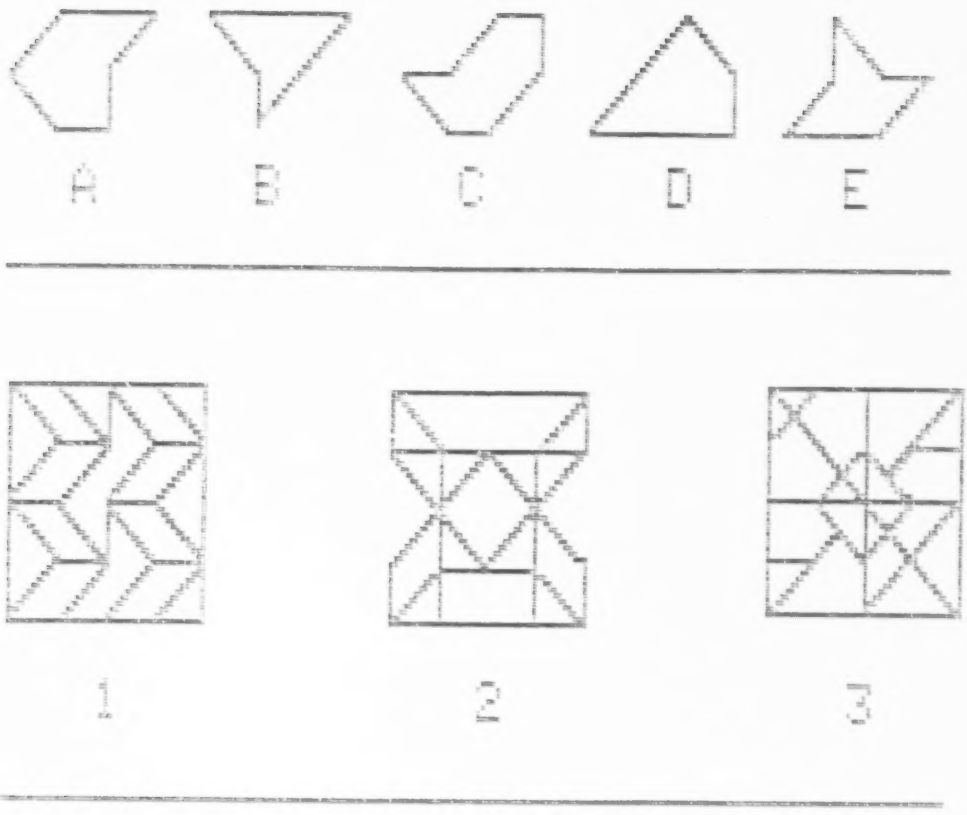


Figure 2
Computer Version of HFT